Chemistry Extended Essay

What impact do time, access to oxygen and ph have on the effectiveness of adsorption of acetic and hydrochloric acids by activated carbon?

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Abstract:

What are the factors that affect the adsorption of activated carbon? One of those factors could be time or pH value or oxygen. Activated carbon is a good tool to show how the adsorption effect works. The research was aimed to test whether the time of the adsorption process has any affect on the titration and final results, to find this out the different periods of time were tested (10min, 20min, 30min). Also the time between the preparation of activated carbon, the sorbent, and its addition into the test tube with the mixture was tested. Another thing that could theoretically influence the result was oxygen and access to it during the reaction, to figure that out some of the test tubes with mixtures were consolidated by corks. The final thing to observe was the influence of ph on the adsorption process, to test it hydrochloric acid (ph=1) and acetic acid (ph=2,87). Summarizing all the listed questions above the final research question can be formulated:

What impact do the time and ph have on the effectiveness of adsorption of acetic and hydrochloric acids by activated carbon?

In order to proceed with the investigation, the specific procedures must be done:

1) Preparing material. Preparation of activated carbon and the acids.
2) Titration. Titration using NaOH as the titration substance.
3) Calculations. Calculation of final concentration of acids, as lower it is as more effectively the adsorption worked out. The main formula is $c_1 * v_1 = c_2 * v_2$ where c is the concentration and v is the volume.

The aim of calculations was to calculate the final concentration of acid in the mixtures, and by that the final result can be estimated.

The main reaction formula is provided here:

$$CH_3COOH + NaOH \rightarrow H_2O + CH_3COONa$$

This reaction occurs after the titration part for the acetic acid. Second main reaction is:

$$HCl + NaOH \rightarrow H_2O + NaCl$$

This reaction occurs after the titration of the second acid which is the hydrochloric one.

Also some variables must be pointed out:

Independent variable: time interval between the beginning of reaction and titration, amount of acids and water.

There will be three different time intervals (10,20 and 30 minutes) to test the influence of time. Also the amounts of acids and water will be changing time by time during the experiment to make data much more diverse.

Dependent variables: influence of pH value, influence of oxygen, influence of time.

There is a possibility that some of those variables impact the adsorption and will be tested.

Controlled variable: amount of activated carbon, temperature.

Amount of activated carbon should remain being approximately about 0,110 grams with an allowed gap of $\pm$0,020 grams from the aimed amount. Also the room temperature of 20°C remains constant during the experiment, so it does not affect the result.

Introduction:

What is adsorption? Basically it is a consumption of one substance by another in a mixture. This effect is used in many ways, especially in medicine. Activated carbon is one of the remedies that use the adsorption as the core reaction. Activated carbon is low carbon pores that increase the surface area of adsorption. A concept of such chemical effect as adsorption was always really interesting for me as I have always been suffering from stomach ache and activated carbon was always the remedy I used to cure my stomach. I, personally, have used the remedy a lot, in cases when I get a food poisoning for example, and it was always pretty helpful. That made me wonder, how does the activated carbon work and what affects it. The factors that could possibly affect it were pretty easy to come up with. One of the most common factors that affects reactions is the time. In this experiment the time between the beginning of the reaction and the end of it was tested. Another factor is an access to oxygen, some beakers were consolidated by corks to prevent the access to oxygen. This allows to test if oxygen affects the reaction. Finally, the ph of acids were tested in term of having an impact on adsorption. To test it acids with different ph were taken.

For the experiment two different acids were selected: hydrochloric and acetic acids. For this experiment I needed both weak and strong acids to illustrate the effect of ph on the final result, if such exists. Hydrochloric acid is a colorless inorganic acid with a specific smell. Its chemical formula is simple: HCL. It has several purposes in industry for example in refining metal, also takes part in production of organic compounds like vinyl chloride. It is considerate as a strong acid as it dissolves completely in reaction. It was chosen as the effect of strength on adsorption must be tested and hydrochloric acid is one of the most famous strong acids. Another acid that was chosen for the experiment is acetic acid. Acetic acid is a weak and colorless acid that has a chemical formula: CH_3COOH. It is usually used as a chemical reagent to produce chemical compounds like vinyl acetate monomer. In this experiment acetic acid represents weak acids, it was chosen for the same reason as hydrochloric acid.

Methodology for Data collection:

For this experiment some equipment must be prepared:

1. Activated carbon
2. Acetic acid
3. Distilled water
4. Pestle and mortar
5. Top pan balance
6. 8 test tubes
7. 8 corks
8. 4 small Erlenmeyer flasks
9. Plastic plate and spoon
10. Notebook and a pencil
11. Timer
12. Titration equipment
13. Hydrochloric acid

Picture 1. Equipment for the experiment.

As this research involves the activated carbon, it needs to be prepared. The process of preparation is simple, just demolishing a pill to an extent that no big pieces are left. After completing this step, the demolished pill must be carried to weights that can measure out a certain amount of activated carbon.

Picture 2. Demolished pill of activated carbon.

Next step is to weight out approximately 0,110 grams of activated carbon and keep this amount of carbon constant as it would make the concluding process way easier. Obviously there will always be uncertainties in measuring out a particular amount of it, but it must be controlled that uncertainties do not exceed the range of 0,020 grams from the taken weight.

Second step is preparing the acids and distilled water by pouring them into separate beakers. Decide what acid must be tested firstly hydrochloric or acetic acid. The amount of water and acids can be taken randomly or like in this case by a specific pattern. In some cases there are much more water than the acid and vice versa. Pour the acid from its beaker into the beaker with water and mix it. To understand it more clearly, imagine that beaker with water is our stomach and somehow acid gets in there, to get rid

of the acid a human must take activated carbon which absorbs the acid. This contributes to the next step.

Put the 0,110 grams of activated carbon into the beaker with mixture. Shake it and make sure that all the activated carbon is floating in the bottom or top of the mixture and nothing is left on the sidepieces of the beaker. Shake it carefully and track the time when it was added to test the time effect on the adsorption. Also, make sure that half of the beakers or test tubes are consolidated with corks, corks prevent the admission of oxygen, what allows to test whether oxygen has impact on the adsorption or not.

Repeat the last steps eight times and wait for the particular amount of time. Some of the test tubes must get covered by corks to prevent the access to oxygen, it is important to have the same amount of acids and water in test tubes with and without corks. The numbers of consolidated and nonconsolidated test tubes must be equal.

Thirdly, after the particular time passes, prepare the titration setup and begin the titration, using $NaOH$. Track and write down the amount of $NaOH$ it takes to color the mixture. When it turns pink or violet, the titration must be stopped and the next test tube must be titrated. The purpose of titration is to measure later the final concentration of the acid. Do titration for all the test tubes.

Repeat the previous steps with different time period between addition of activated carbon in the mixture and the titration. The time periods must be 10, 20 and 30 minutes.

Repeat all the steps with different acid. Take another acid, but use the same amounts of acid and water. Time periods must remain the same as well.

Final step is calculation of the final concentration of the acids and finding out if any patterns are present. First of all ph values for the acids must be calculated to figure out if ph value somehow affects the effectiveness of adsorption. The needed formula is presented here:

Where:

To calculate the final concentration of the acids, this formula must be used:

$$\frac{c_1 * v_1}{n_1} = \frac{c_2 * v_2}{n_2}$$

Where:

c_1 is the beginning concentration of acid

v_1 is the beginning volume of the acid (ml)

c_2 is the final concentration of the acid

v_2 is the volume of the titration substance (ml)

n_1 is the coefficient of the acid

n_2 is the coefficient of titration substance

As the task is to find the final concentration, the formula must be changed a bit:

$$c_2 = \frac{c_1 * v_1}{v_2}$$

The units and variables remain the same. Using this formula, final concentration of acids must be calculated for all data pieces. After that the pattern between the different ph, strength, time and accessibility to oxygen must be figured out.

Data:

Data pieces that are colored in red mean that the test tube was consolidated by a cork to prevent an admission of oxygen. This was made to test if Oxygen influences the reaction anyhow.

Table №1. Data of the first attempt.

Run	Volume of Water (ml) $\pm 0{,}1ml$	Volume of acetic acid (ml) $\pm 0{,}1ml$	Time(min) $\pm 0{,}1min$	Mass of Activated Carbon (gr) $\pm 0{,}0001\ gramm$
1	3	1	10	0,110
2	5	2	10	0,109
3	5	2	10	0,117
4	6	3	10	0,101
5	6	3	10	0,105
6	3	4	10	0,114
7	3	1	10	0,118
8	3	4	10	0,111

Table №2. Data of the first attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	1,6	4
2	7	2,5	4
3	7	2,7	4
4	9	3,3	4
5	9	3,1	4
6	7	4,9	4
7	4	1,6	4
8	7	4,1	4

Table №3. Data of the second attempt.

Run	Volume of Water (ml) $\pm 0{,}1ml$	Volume of HCL (ml) $\pm 0{,}1ml$	Time (min) $\pm 0{,}1min$	Mass of Activated Carbon(gr) $\pm 0{,}0001 gramms$
1	3	1	10	0,109
2	5	2	10	0,115
3	5	2	10	0,107
4	6	3	10	0,121
5	6	3	10	0,108
6	3	4	10	0,117
7	3	1	10	0,107
8	3	4	10	0,122

Table №4. Data of the second attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	2,1	4
2	7	3,2	4
3	7	2,2	4
4	9	3,4	4
5	9	3,2	4
6	7	4,7	4
7	4	1,3	4
8	7	3,8	4

Table №5. Data of the third attempt.

Run	Volume of Water (ml) $\pm 0{,}1ml$	Volume of acetic acid (ml) $\pm 0{,}1ml$	Time(min) $\pm 0{,}1min$	Mass of Activated Carbon (gr) $\pm 0{,}0001grams$
1	3	1	20	0,102
2	5	2	20	0,114
3	5	2	20	0,106
4	6	3	20	0,108
5	6	3	20	0,115
6	3	4	20	0,109
7	3	1	20	0,111
8	3	4	20	0,113

Table №6. Data of the third attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	1,1	4
2	7	2,8	4
3	7	2,0	4
4	9	3,8	4
5	9	3,3	4
6	7	5,0	4
7	4	1,4	4
8	7	4,2	4

Table №7. Data of the fourth attempt.

Run	Volume of Water (ml) $\pm 0{,}1ml$	Volume of HCL (ml) $\pm 0{,}1ml$	Time(min) $\pm 0{,}1min$	Mass of Activated Carbon (gr) $\pm 0{,}0001gramms$
1	3	1	20	0,106
2	5	2	20	0,114
3	5	2	20	0,117
4	6	3	20	0,101
5	6	3	20	0,104
6	3	4	20	0,107
7	3	1	20	0,119
8	3	4	20	0,109

Table №8. Data of the fourth attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	1,0	4
2	7	2,1	4
3	7	2,1	4
4	9	3,6	4
5	9	3,9	4
6	7	4,7	4
7	4	1,2	4
8	7	4,6	4

Table №9. Data of the fifth attempt.

Run	$Volume\ of\ H_2O(ml)$ $\pm 0{,}1ml$	$Volume\ of\ Acetic\ Acid(ml)$ $\pm 0{,}1ml$	Time(min) $\pm 0{,}1min$	Mass of Activated Carbon (gr) $\pm 0{,}0001 gramms$
1	3	1	30	0,104
2	5	2	30	0,109
3	5	2	30	0,103
4	6	3	30	0,111
5	6	3	30	0,114
6	3	4	30	0,127
7	3	1	30	0,111
8	3	4	30	0,109

Table №10. Data of the fifth attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	1,0	4
2	7	3,0	4
3	7	2,0	4
4	9	9,0(uncertainty)	4
5	9	3,3	4
6	7	4,4	4
7	4	1,4	4
8	7	4,5	4

Table №11. Data of the sixth attempt.

Run	$Volume\ of\ H_2O(ml)$ $\pm 0{,}1ml$	$Volume\ of\ HCL(ml)$ $\pm 0{,}1ml$	Time (min) $\pm 0{,}1min$	Mass of Activated Carbon $\pm 0{,}0001 gramms$
1	3	1	30	0,117
2	5	2	30	0,103
3	5	2	30	0,111
4	6	3	30	0,109
5	6	3	30	0,103
6	3	4	30	0,107
7	3	1	30	0,112
8	3	4	30	0,110

Table №12. Data of the sixth attempt after titration.

Run	Amount of substance (ml) $\pm 0{,}1ml$	Amount of Naoh (ml) $\pm 0{,}01ml$	Amount of phenolphthalein (number of drops)
1	4	1,2	4
2	7	2,0	4
3	7	2,5	4
4	9	3,7	4
5	9	3,1	4
6	7	4,1	4
7	4	1,2	4
8	7	4,2	4

Processed results:

Firstly, the pH of acids (hydrochloric and acetic) must be calculated. pH of acids are needed for the identifying the pattern of ph influence on the effectiveness of adsorption, if such exists. The required formula for this part is:

$$pH\ (soluion) = -log_{10}[H+]$$

Where $[H+]$ is the concentration of hydrogen in the solution.

So, the first acid which pH should be calculated is hydrochloric one. The order in which pH of acids should be calculated does not matter. The calculations are provided here:

$$pH\ (HCl) = -log_{10}[H+] = -log_{10}[0{,}1] = 1$$

However, calculations for acetic acid are not that simple as for HCl, as acetic acid is a weak one and does not dissociate completely in the solution. To calculate it, several steps must be gone through:

First of all, expression of pKa value:

$$pKa = -log_{10}[Ka]$$

Where square brackets represent the concentration.

Ka for acetic acid equals to:

$$Ka = \frac{[H+] * [CH_3COO-]}{[CH_3COOH]}$$

This means that pKa equals to:

$$pKa = log_{10}[CH_3COOH] - log_{10}[H+] - log_{10}[CH_3COO-]$$

As $log_{10}[H+]$ equals to $log_{10}[CH_3COO-]$:

$$pKa = log_{10}[CH_3COOH] - 2log_{10}[H+]$$

For acetic acid pKa equals to 4,76 and $pH\ (acetic\ acid) = -log_{10}[H+]$:

$$4{,}76 = log_{10}0{,}1 + 2 * pH$$

$$2 * pH = 5{,}76$$

$$pH = 2{,}88$$

Next step is calculation of the final concentration of acids. The formula, which helps to find it is:

$$\frac{c_1 * v_1}{n_1} = \frac{c_2 * v_2}{n_2}$$

So here is how the main calculations are made, as an example of the calculations the data from the very first run of acetic acids was taken:

First of all, the coefficients must be stated. To do that the reaction equation must be looked over again, the coefficients that are required to be stated are that of the acids and that of the titration substance (in this case sodium hydroxide):

$$1CH_3COOH + 1NaOH \rightarrow 1H_2O + 1CH_3COONa$$

As it can be seen in this case the coefficients in front of the acid and titration substance are equal to 1. This allows crossing both n_1 and n_2 out as those are the same values. This is the final state of the formula:

$$c_1 * v_1 = c_2 * v_2$$

Next step is to put all the known values in the formula, those values are the concentration of the acids and the volumes of sodium hydroxide and the acids as well:

1) $0{,}1 * 1 = c_2 * 1{,}6$

Final step is to change formula so that it would be more convenient to calculate the final concentration and find the value:

2) $c_2 = \frac{c_1 * v_1}{v_2} \rightarrow \frac{0{,}1 * 1}{1{,}6} = 0{,}062$

That was the very first data set for acetic acid with a time period of 10. Just to make it clearer, the same work, but with hydrochloric acid must be made. The calculation of the very first data set for hydrochloric acid with a time period of 10:

First of all, the coefficients must be stated:

$1HCl + 1NaOH \rightarrow 1H_2O + 1NaCl$

Just like in the first example the coefficients are the same, this means that they can be crossed out:

$c_1 * v_1 = c_2 * v_2$

Finally, calculation of the final concentration of the acid:

1) $c_2 = \frac{c_1 * v_1}{v_2} \rightarrow \frac{0{,}1 * 1}{2{,}1} = 0{,}047$

As it can be seen, the final concentration of hydrochloric acid is lower than that of acetic acid even though both had the same amounts of acids, both were not consolidated and had the same time period. It means that ph of acid actually influences the adsorption. However, it was just a hypothesis as only two data sets were compared. To prove that much more data samples must be compared.

After finding the final concentration, it should be compared to the starting concentration which is 0,1. If the concentration was decreased significantly, it means that adsorption was successful. Considering the examples above the adsorption was successful as the concentration changed from 0,1 to 0,06 and 0,05.

However there are some cases where adsorption did not work out like in the second run of HCL with a time period of 30 minutes as the final concentration does not really differ from that of an original one.

The same procedure must be made for the rest of the data, to all 47 data sets that are remaining. It is a huge work, but it will clearly show the patterns. Here is the table with the final values:

Table 13. The final concentration of the acetic acid after titration for all the time periods.

Runs	Final concentration of acid with the time period of 10 minutes $\pm 0{,}0001$	Final concentration of acid with the time period of 20 minutes $\pm 0{,}0001$	Final concentration of acid with the time period of 30 minutes $\pm 0{,}0001$
1	0,062	0,090	0,100
2	0,080	0,071	0,060
3	0,074	0,100	0,100
4	0,090	0,078	0,030
5	0,096	0,090	0,090
6	0,081	0,080	0,090
7	0,062	0,071	0,071
8	0,097	0,095	0,088

Graph 1. The final concentration of the hydrochloric acid after titration for all the time periods.

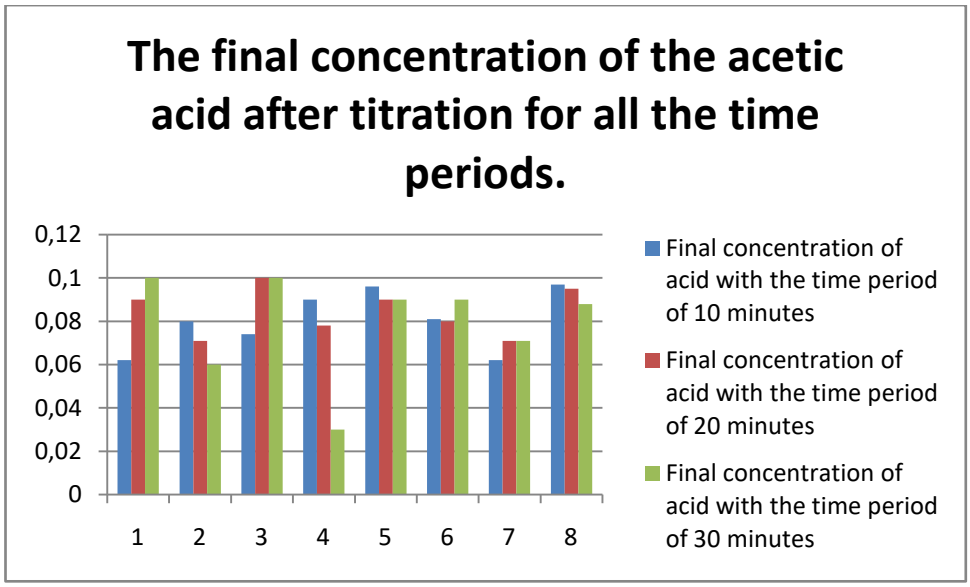
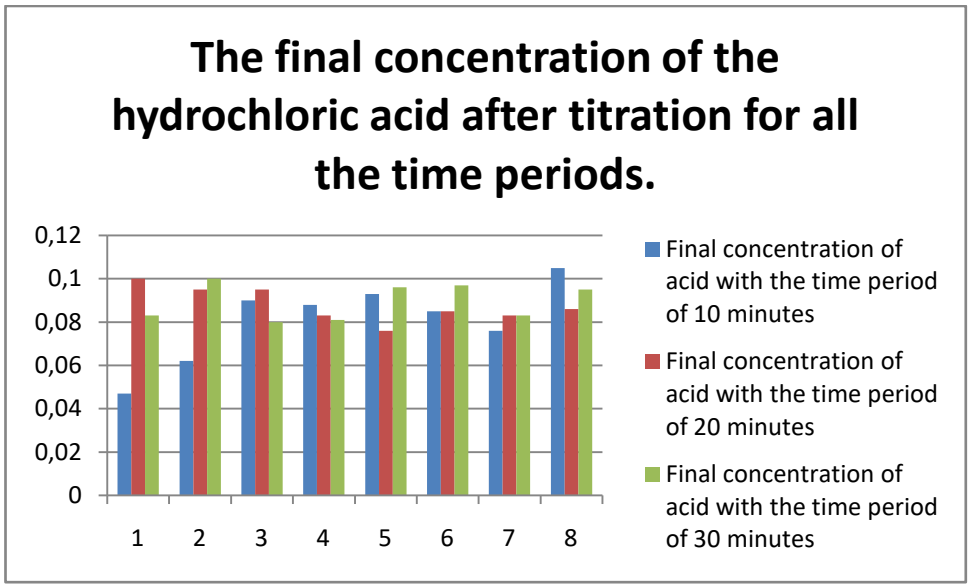


Table 14. The final concentration of the hydrochloric acid after titration for all the time periods.

Runs	Final concentration of acid with the time period of 10 minutes $\pm 0{,}0001$	Final concentration of acid with the time period of 20 minutes $\pm 0{,}0001$	Final concentration of acid with the time period of 30 minutes $\pm 0{,}0001$
1	0,047	0,100	0,083
2	0,062	0,095	0,100
3	0,090	0,095	0,080
4	0,088	0,083	0,081
5	0,093	0,076	0,096
6	0,085	0,085	0,097
7	0,076	0,083	0,083
8	0,105	0,086	0,095

Graph 2. The final concentration of the hydrochloric acid after titration for all the time periods.



To figure out if access to oxygen has any impact on the adsorption, the final concentrations of the same time period and amount of substances but with and without corks must be tested. To figure it out for each acid and for each time period the final concentrations must be compared. To do so the final concentration of a sample without cork must be subtracted from that of with cork.

Here is the table with the results:

Table 15. Comparison of final concentration's values for samples with and without corks for acetic acid.

Runs	Concentrations value of sample with cork minus that of without cork for time period of 10 minutes $\pm 0{,}0001$	Concentrations value of sample with cork minus that of without cork for time period of 20 minutes $\pm 0{,}0001$	Concentrations value of sample with cork minus that of without cork for time period of 30 minutes $\pm 0{,}0001$
1 and 7	0,000	-0,019	-0,029
2 and 3	-0,006	0,029	0,094
4 and 5	0,006	0,012	0,060
6 and 8	0,016	0,005	-0,002

Table 16. Comparison of final concentration's values for samples with and without corks for hydrochloric acid.

Runs	Concentrations value of sample with cork minus that of without cork for time period of 10 minutes $\pm 0{,}0001$	Concentrations value of sample with cork minus that of without cork for time period of 20 minutes $\pm 0{,}0001$	Concentrations value of sample with cork minus that of without cork for time period of 30 minutes $\pm 0{,}0001$
1 and 7	0,029	-0,017	0,000
2 and 3	0,028	0,000	-0,020
4 and 5	0,005	-0,006	0,017
6 and 8	0,020	0,001	-0,002

By looking at the data above, it can be clearly stated that most of the differences are positive (54%). What means that concentration values of samples with corks are greater, which means that adsorption in samples with corks was not that much effective as in that of without corks, at least in 54% of all cases. By that it can be stated that most likely access to oxygen improves the effect of adsorption. However, on the other hand it is true only in 54%, when in 33% it works in opposite way (the remaining 13% come on the cases when there is no difference between the values).

To find out if the time period between the addition of activated carbon and titration influences the adsorption, data sets with the same amount of substances and presence of cork but with different time periods must be compared. Basically, the same operation as the last one must be made. The results are presented below:

Table 17. Comparison of the final concentration values on different time periods 10/20/30 of samples with acetic acid.

Runs	Final concentration values on different time periods 10/20/30 $\pm 0{,}0001$
1	0,062 / 0,090 / 0,100
2	0,080 / 0,071 / 0,060
3	0,074 / 0,100 / 0,100
4	0,090 / 0,078 / 0,030
5	0,096 / 0,090 / 0,090
6	0,081 / 0,080 / 0,090
7	0,062 / 0,071 / 0,071
8	0,097 / 0,095 / 0,088

Table 18. Comparison of the final concentration values on different time periods 10/20/30 of samples with hydrochloric acid.

Runs	Final concentration values on different time periods 10/20/30 $\pm 0{,}0001$
1	0,047 / 0,100 / 0,083
2	0,062 / 0,095 / 0,100
3	0,090 / 0,095 / 0,080
4	0,088 / 0,083 / 0,081
5	0,093 / 0,076 / 0,096
6	0,085 / 0,085 / 0,097
7	0,076 / 0,083 / 0,083
8	0,105 / 0,086 / 0,095

It is really hard to state anything from this data as most of the values are spread randomly without any pattern. However, statistically 31% of the sample's values are decreasing as time period increases. While only in 18% of the cases the value increases as time period increases. This means that mostly there will not be any pattern in terms of dependence of adsorption on the time period between titration and the beginning of reaction. Despite that conclusion, the 25% chance of getting the decrease in concentration values cannot be denied.

To find out if ph has any influence on the adsorption, data sets with the same presence of cork and time periods but different acids must be compared. To make this comparison real, another table must be made:

Table 19. Comparison of the final concentration values of different acids.

Runs	Final concentration values of acetic acid for all the time periods 10/20/30 $\pm 0{,}0001$	Final concentration values of hydrochloric acid for all the time periods 10/20/30 $\pm 0{,}0001$
1	0,062 / 0,090 / 0,100	0,047 / 0,100 / 0,083
2	0,080 / 0,071 / 0,060	0,062 / 0,095 / 0,100
3	0,090 / 0,100 / 0,100	0,090 / 0,095 / 0,080
4	0,090 / 0,078 / 0,030	0,088 / 0,083 / 0,081
5	0,096 / 0,090 / 0,090	0,093 / 0,076 / 0,096
6	0,081 / 0,080 / 0,090	0,085 / 0,085 / 0,097
7	0,062 / 0,071 / 0,071	0,076 / 0,083 / 0,083
8	0,097 / 0,095 / 0,088	0,105 / 0,086 / 0,095

By looking at the table above it can be deduced that pH actually influences the effectiveness of adsorption. According to the table, in 58% of all cases the concentration of acid is less for acetic acid, what means that it was better adsorbed than the other one. Also, according to the previous calculations the pH of acetic acid (2,88) is way greater than that of hydrochloric acid (1). Contributing from that, as higher the pH of acid is as more of it gets adsorbed.

Evaluation and Discussion:

This method has several advantages and disadvantages. The most essential advantage is its ease to realize. The main procedure is in a way easy but requires some particular knowledge and a lot of hard work to assemble it fully. Another advantage is that this experiment and the research question allows to look at the topic from different angles and opens doors for some further researches. Another reason to fulfill this method is that it does not require any rare equipment nor chemicals, those can be founded at any lab. Moreover, titration is a great choice for the main procedure of finding the final concentration of the acid, because it can be always rechecked, clearly shows how the reaction works and there are no other available for everyone ways to do that. However, there are some disadvantages of the method. First of all, loss of some reactants like activated carbon during the process might be an issue leading to irrelevance of data. Another issue of this method is that it does not really cover other factors that might affect the result, like temperature. One last disadvantage of this method is that it depends too much on the quality of titration's equipment, if the equipment is somehow damaged or does not work properly it will critically impact the data and the result as well.

Conclusion:

Completing this research was a big challenge for me as it required a lot of time and strength to fulfill it. After finishing it I learned a lot of how the activated carbon works, what factors actually influence the reactions and which do not. Surely, this method and the research as well do have some limitations like dependence on equipment, possible loss of material and a big bunch of calculations, but it also has many positive sides. One of those is that it contributes to some global issues like intoxication, which are getting resolved by adsorbents like activated carbon. Also it contributes to many industrial fields where the process of adsorption plays essential role. Moreover, as it was mentioned before, this research can be extended in some particular ways; for example, the effect of temperature ore pressure can be studied. Speaking of the actual results of the research, several conclusions can be made. Firstly, the time period between titration and the beginning of the reactions does not affect the final concentration of acid in any ways. Even increase or decrease in time periods will not lead to anything in most cases; however there is a small possibility of some patterns in increase and decrease of concentration value to appear as in 51% no patterns occur. Secondly, pH of reacting acids does influence the final concentration of acids. As higher the pH value is, as more of acid gets adsorbed. To prove that both weak and strong acids were compared. Finally, in most of the cases the presence of oxygen does improve the adsorption of acids by activated carbon. To test it, the corks were used to consolidate test tubes. Concluding all of those conclusions, the factors that actually affect the effectiveness of adsorption of acids by activated carbon are pH value and the access to oxygen.

Bibliography:

Quora. (2019). *What is pKa value?*. [online] Available at: https://www.quora.com/What-is-pKa-value [Accessed 10 Jan. 2019].

Encyclopedia Britannica. (2019). *Adsorption | surface phenomenon*. [online] Available at: https://www.britannica.com/science/adsorption [Accessed 4 Aug. 2018].

ChemicalSafetyFacts.org. (2019). *Hydrochloric Acid | Muriatic Acid | Chemical Safety Facts*. [online] Available at: https://www.chemicalsafetyfacts.org/hydrochloric-acid/ [Accessed 6 Jan. 2019].

Sciencedirect.com. (2019). *Acetic Acid - an overview | ScienceDirect Topics*. [online] Available at: https://www.sciencedirect.com/topics/neuroscience/acetic-acid [Accessed 2 Aug. 2018].

User, S. (2019). *Activated Carbon | What is Activated Carbon | Benefits*. [online] Haycarb.com. Available at: https://www.haycarb.com/activated-carbon [Accessed 10 Aug. 2018].

Owen, S. (2014). *Chemistry for the IB Diploma Coursebook with Free Online Mat*. 2nd ed. pp.43,44.